FLORA W. PATTERSON.

UNIVERSITY OF CALIFORNIA PUBLICATIONS

COLLEGE OF AGRICULTURE
AGRICULTURAL EXPERIMENT STATION
BERKELEY, CALIFORNIA

IMPERIAL BUREAU OF MYCOLOGY
13 JUL 1921

Melaxuma of the Walnut, "Juglans regia"

(A PRELIMINARY REPORT)

By HOWARD S. FAWCETT

BULLETIN No. 261

Berkeley, Cal., November, 1915

CALIFORNIA
STATE PRINTING OFFICE
1915

19511

BENJAMIN IDE WHEELER, President of the University.

EXPERIMENT STATION STAFF

HEADS OF DIVISIONS

THOMAS FORSYTH HUNT, Director.
EUGENE W. HILGARD, Agricultural Chemistry (Emeritus).
EDWARD J. WICKSON, Horticulture (Emeritus).
HERBERT J. WEBBER, Director Citrus Experiment Station; Plant Breeding.
HUBERT E. VAN NORMAN, Vice-Director; Dairy Management.
WILLIAM A. SETCHELL, Botany.
MYER E. JAFFA, Nutrition.
ROBERT H. LOUGHRIDGE, Soil Chemistry and Physics (Emeritus).
CHARLES W. WOODWORTH, Entomology.
RALPH E. SMITH, Plant Pathology.
J. ELIOT COIT, Citriculture.
JOHN W. GILMORE, Agronomy.
CHARLES F. SHAW, Soil Technology.
JOHN W. GREGG, Landscape Gardening and Floriculture.
FREDERIC T. BIOLETTI, Viticulture and Enology.
WARREN T. CLARKE, Agricultural Extension.
JOHN S. BURD, Agricultural Chemistry.
CHARLES B. LIPMAN, Soil Chemistry and Bacteriology.
CLARENCE M. HARING, Veterinary Science and Bacteriology.
ERNEST B. BABCOCK, Genetics.
GORDON H. TRUE, Animal Husbandry.
JAMES T. BARRETT, Plant Pathology.
FRITZ W. WOLL, Animal Nutrition.
A. V. STUBENRAUCH, Pomology.
WALTER MULFORD, Forestry.
W. P. KELLEY, Agricultural Chemistry.
H. J. QUAYLE, Entomology.
ELWOOD MEAD, Rural Institutions.
J. B. DAVIDSON, Agricultural Engineering.
H. S. REED, Plant Physiology.
WILLIAM G. HUMMELL, Agricultural Education.
LEON M. DAVIS, Dairy Industry.
JOHN E. DOUGHERTY, Poultry Husbandry.
FRANK ADAMS, Irrigation Practice.
DAVID N. MORGAN, Assistant to the Director.
MRS. D. L. BUNNELL, Librarian.

DIVISION OF SOIL CHEMISTRY AND BACTERIOLOGY.

C. B. LIPMAN
L. T. SHARP
W. F. GERICKE
M. A. KLEIN
L. E. BAILEY

CONTENTS.

	Page
Introduction	133
Description of the Disease	133
Investigation as to Cause of Melaxuma	134
Previous Work	134
Inoculations with Diseased Tissue	134
Inoculations with Cultures of Dothiorella	136
Reisolation of the Fungus	137
Willows Affected with Melaxuma	137
Tabulated Results of Inoculations on Walnut and Willow Trees	138
The Fungus	140
Probable Methods of Natural Infection	140
Experiment for Control	143
Treatment Suggested	145
Summary	148

MELAXUMA OF THE WALNUT, JUGLANS REGIA.*

(PRELIMINARY REPORT.)

HOWARD S. FAWCETT.

INTRODUCTION.

It is the purpose of this bulletin to report the results of an investigation begun in June, 1913, relating to the cause and control of a comparatively new disease of English walnut trees in California. This disease, known as Melaxuma, which occurs in the form of black cankers in the crotches and limbs, and occasionally in the form of a sudden wilting and dying of the branches, has been noticed by walnut growers in Santa Barbara County for a number of years (at least since 1909), but has only attracted serious attention during the past two or three years.

Because of the oozing of dark watery material to the surface of affected areas, this disease is often confused, under the name of "black sap," with sunburn, frost injury, injuries to the bark in cultivation, injury from the decay of wood at places where limbs have been cut off, and other troubles in which a "black sap" may ooze out during the active growing period of the tree. It should not be taken for granted, therefore, that because a black ooze is seen on the trunk or larger limbs of a walnut tree that Melaxuma is necessarily present.

As the term "black sap" has already been used by R. E. Smith† to designate a result of sunburning, this name was not considered suitable for the disease here being considered. The word Melaxuma, derived from two Greek words meaning "black" and "juice," was therefore adopted and is now in fairly common use to designate the disease herein described.

DESCRIPTION OF THE DISEASE.

Melaxuma shows its effect most strikingly during the summer after the growth is well started. On trees severely affected at that time, there will be seen large black sunken cankers on the trunk and larger limbs and often a sudden wilting of smaller limbs and twigs. This sudden wilting of the smaller limbs is so different from the effects of walnut blight or bacteriosis, that it is easily distinguished from that disease.

The most common location for Melaxuma cankers is at the crotch of the tree where the first limbs join the trunk. (Fig. 1.) The first evidence of the disease is often a black area on the otherwise greyish bark which looks like a dab of tar. (Fig. 2.) This is due to the

*Paper No. 18, Citrus Experiment Station, College of Agriculture, University of California, Riverside, California.

†"Walnut Culture in California," Bulletin 231, page 373.

staining of the bark by a black watery substance that forms under it. The diseased area later becomes slightly sunken, shrinks and cracks. The "black sap" then oozes out in considerable quantities and stains the bark as it runs down the limb or trunk. The wood underneath is discolored for a short distance and this discoloration usually extends beyond the margin of the killed bark. The diseased areas, as a rule, do not extend entirely around a limb in one season, but affect only about one-third or one-half the circumference of the bark. (Fig. 3.) Later in the summer or fall the increase in the size of the areas is slower and often appears to be stopped. Part of the margin of the canker may dry out and begin to heal over, while the other continues to advance or remains stationary until the next spring when it begins to advance rapidly again. A few cankers on large limbs of vigorous trees may even heal over without treatment, but this rarely takes place. More often there is an enlargement from year to year which in two or more years extends entirely around a large limb, causing it to wilt and die. (Fig. 1, A and B.) These limbs occasionally wilt suddenly, the dried-up nuts and leaves remaining attached for some time. When cankers occur on the trunks they generally follow some injury to the bark made by a plow, cultivator or other instruments used in the cultivation of the orchard.

Further out on the larger branches diseased cankers usually start either at the forks of branches or at the base of a small twig which has first been killed back to the larger branch. In trees severely attacked, the bark and wood on branches one-fourth to one-half inch in diameter may be killed rapidly and the entire branch beyond the affected place suddenly withered. The dried leaves and half-formed nuts often remain attached to the branch. In many cases, the smaller branches are not so commonly affected as the larger ones.

INVESTIGATION AS TO THE CAUSE OF MELAXUMA.

Previous work.

The first investigation of the disease was begun in the early part of 1913, by W. H. Nixon and C. A. Hollister, students of the University of California, who proved that the disease was infectious by transmitting it from diseased cankers to perfectly healthy limbs by means of cuts with an infected ax or chisel, and also by inserting pieces of diseased bark from active cankers into healthy limbs. Mr. Hollister had noticed that in an orchard pruned with an ax, a year or so before, the disease had apparently been spread from a few diseased trees over a greater part of the orchard.

Inoculations with diseased tissue.

In June, 1913, while the writer was with the California State Commission of Horticulture, a further investigation of the disease was

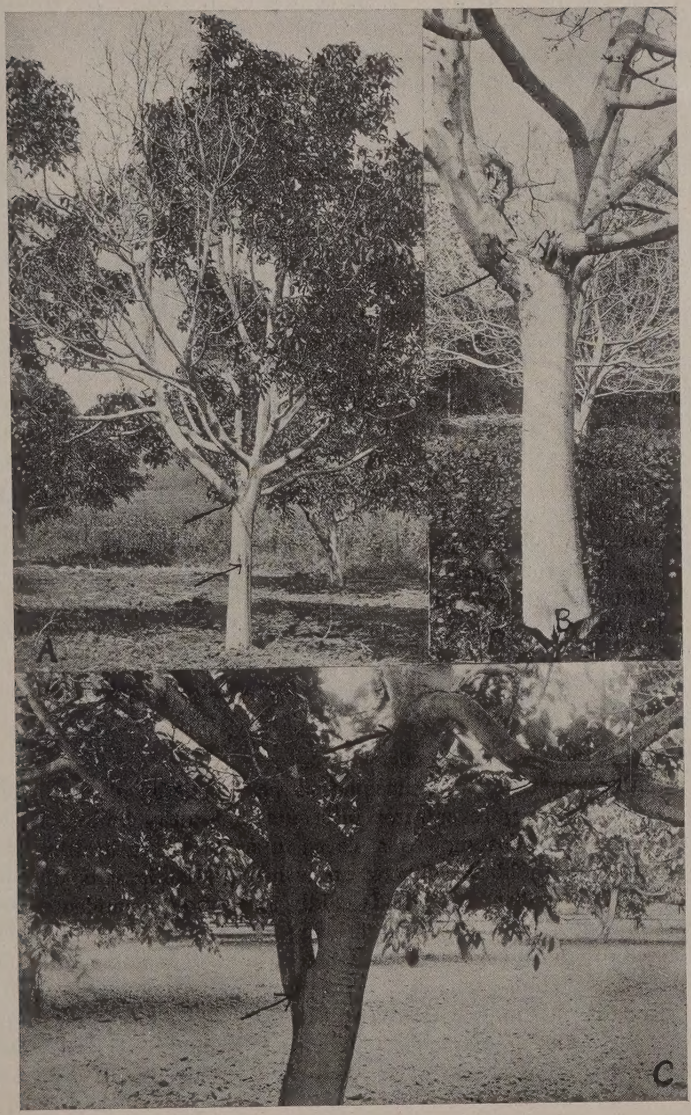

FIG. 1. Melaxuma on walnut trees. (A) Showing limbs killed by the disease. (B) Showing old cankers from which the bark has fallen away. (C) Showing a number of cankers from which "black sap" is oozing. The arrows denote the location of cankers.

taken up, not only at the request of Mr. C. W. Beers, Horticultural Commissioner of Santa Barbara County, but also at the request of Messrs. Nixon and Hollister, who did not wish to continue further with the work. The experiments that Nixon and Hollister had started were examined. About twenty inoculations had been made into healthy limbs; seven with diseased bark, five with knives or chisels that had first been infected by cutting into active cankers, and eight with an ax infected in the same way. Six cuts with sterilized instruments had also been made as checks. The bark of the limbs had been disinfected with corrosive sublimate, 1–1000, previous to inoculation and afterwards wrapped with paraffined paper. In from one to two months nearly all the inoculations were showing infection and later developed typical Melaxuma cankers. One of the check cuts had become accidently infected. The others were healing normally.

Late in June, 1913, further inoculation experiments by the writer with material not only from the diseased cankers, but from the smaller withered limbs, showed the same results as those obtained by Nixon and Hollister. In these inoculation experiments, diseased bark and wood was taken from active cankers on large limbs and put into both large and small limbs, and diseased bark was also taken from small withering limbs and put into both large and small limbs, with the result that the withering of the smaller limbs and the production of the characteristic black cankers were proved to be due to the same cause. At this time a fungus, a species of *Dothiorella,* was discovered in these diseased cankers and also on the withered limbs, and pure cultures were obtained.

Inoculations with cultures of Dothiorella.

In the latter part of July, inoculations were made by placing bits of fungus from these pure cultures into cuts in healthy limbs. It was found that when this fungus was placed in small cuts in healthy large limbs, it produced black cankers, and when placed in cuts in small limbs, it killed the bark and wood rapidly and caused a sudden wilting of the branch beyond; both effects being characteristic of the disease as it occurs naturally. Similar cuts made in another part of the same tree in healthy limbs without the insertion of the fungus healed up perfectly without producing any cankers or causing any "black sap" to run out. One of these inoculations will be described (the results of the others are given in Tables 1 and 2): This inoculation was made on a two and one-half inch limb July 31, 1913, by inserting a bit of fungus from a pure culture into a small cut, and tying paraffined paper over it. A similar cut was made and wrapped two feet further out on the same limb without the insertion of the fungus.

On September 17, 1913, an area of bark 2½ inches long and 2 inches wide, surrounding the inoculated cut, was black and a dark watery liquid was oozing from it.

By April 29, 1914, the killed area, now a typical Melaxuma canker, had become 4½ inches long and had involved about two-thirds of the circumference of the limb. Abundant pycnidia of *Dothiorella* were present over an area 2 by 1 inches and the affected bark was sunken and cracked with dark liquid oozing out at one edge where the canker appeared to be enlarging. On the other edge the progress of the fungus had apparently been stopped.

The limb was cut off at this time and the greatest depth to which the wood underneath was stained was found to be about one-fourth of an inch. The check cut two feet further out had healed perfectly without dying of bark or oozing of "black sap." A considerable number of similar inoculations, giving similar results (see Tables 1 and 2), seemed to prove conclusively that this fungus was the causal agent in producing the disease.

Reisolation of the fungus.

Pure cultures of the fungus, the same that had been used in the inoculation, were isolated from bits of the inner bark from the outermost edge of the affected area of the inoculation just described. The fungus was also reisolated from seven other artificially produced cankers of inoculations recorded in Table 1.

WILLOWS AFFECTED WITH MELAXUMA.

In August, 1914, cankers identical with those on walnut trees were discovered in the arroyo willow (*Salix lasiolepis*) in Santa Barbara County. On microscopic examination, the same fungus appeared to be present on the willows, and the same fungus was isolated from them. Inoculations were then made by inserting the fungus in cuts in the healthy bark of both walnut and willow trees, with the result that typical Melaxuma cankers were produced on both the walnut and the willow. (Fig. 4.) Cankers were found on willow trees not only on the edge of walnut orchards but on trees growing far removed from walnut orchards. It is believed that the disease may have originally come from the willows to the walnut trees. The transmission of the disease in many cases was probably hastened by the former practice of propping the lower limbs of walnut trees with poles cut from the nearby willows. Willows in many sections of California are commonly attacked by certain borers, but the Melaxuma cankers are quite distinct from the typical borer injury.

TABULATED RESULTS OF INOCULATIONS ON WALNUT AND WILLOW TREES.

The general results of the inoculation experiments have already been discussed under the heading of "Investigations as to the Cause." These inoculations were made in order to prove definitely whether or not the disease was infectious, and whether the *Dothiorella* fungus found commonly associated with it, had anything to do with its occurrence. In all these experiments, except Nos. 12 and 13, small cuts were made through the bark with a sharp sterile knife and the material for inoculation inserted, after which the cuts were covered with paraffined paper held with raffia. In most cases, the bark at the place where the inoculation was to be made was first cleansed by rubbing with a cloth moistened with alcohol. As will be seen in the table, there were made with nearly every cut for an inoculation, a similar cut into which nothing was placed, this being a check for the purpose of comparison to determine whether or not the cutting of the bark alone would cause the cankers to form. It will be seen from the results that every one of these check cuts healed. From only one check cut a small amount of "black sap" oozed before healing.

TABLE 1. INOCULATIONS ON WALNUT TREES.

No.	Date made	Source of inoculation material	Diameter of limb inoculated	Results	
1	June 26, 1913	Bit of bark from withered twig	3 inches	July 31, 1913	Killed area 2x8 inches, black sap flowing.
2	June 26, 1913	Check	3 inches	July 31, 1913	Healed perfectly.
3	June 26, 1913	Bark from canker in crotch	½ inch	July 31, 1913	Branch killed, leaves withered, and pycnidia forming on bark.
4	June 26, 1913	Bit of discolored wood from canker	½ inch	July 31, 1913	Small area 1x2 inches.
5	June 26, 1913	Check	½ inch	July 31, 1913	Healed.
6	June 26, 1913	Bark containing pycnidia of Dothiorella	½ inch	July 31, 1913	Small area of bark killed.
7	June 26, 1913	Check	½ inch	July 31, 1913	Healed perfectly.
8	June 26, 1913	Culture of fungus (Dothiorella)	½ inch	Sept. 17, 1913	Limb surrounded by a band of killed bark; 12 inches at greatest length. Pycnidia numerous.
9	June 26, 1913	Check	½ inch	Sept. 17, 1913	Healed perfectly.
10	June 26, 1913	Culture of fungus (Dothiorella)	¾ inch	Sept. 17, 1913	Entire branch beyond cut withered.
11	June 26, 1913	Check	¾ inch	Sept. 17, 1913	Healed perfectly.
12	June 23, 1913	Culture of Dothiorella on uncut surface of bark.	¾ inch	Sept. 17, 1913	No infection.
13	June 26, 1913	Check	¾ inch	Sept. 17, 1913	No infection.
14	April 29, 1914	Culture of fungus (Dothiorella)	2 inches	Aug. 7, 1914	Killed area 4x2 inches and black sap oozing out.
15	April 29, 1914	Check	2 inches	Aug. 7, 1914	Wound healing. Slight amount of black sap oozing from cut.. Cut healed completely later.
16	April 29, 1914	Culture of fungus (Dothiorella)	1 inch	Aug. 7, 1914	Killed area 2x4 inches and black sap oozing.
17	April 29, 1914	Check	1 inch	Aug. 7, 1914	Healed.

TABLE 2.

Comparative inoculations on one and one-half inch limbs of walnut and willow trees with two different cultures of *Dothiorella gregaria*, August 4, 1914.

Results on December 31, 1914.

	Inoculations on	
	Walnut (Juglans regia)	Willow (Salix lasiolepis)
Culture 1	Killed area 6 inches long, 2 inches wide. Bark sunken and black sap flowing. Fig. 4a.	Killed area 4 inches long and 2 inches wide. Bark sunken, dark sap not so conspicuous. Fig. 4b.
Culture 2	Killed area 3 inches long by 1½ inches wide, otherwise as above.	Killed area 3 inches long, 1 inch wide, otherwise as above.
Check	Cut healed perfectly.	Cut healing.

THE FUNGUS.

On the surface of the dead bark of the Melaxuma cankers, usually some weeks after they first begin to show, will be seen minute dark pustules which have formed in the bark and pushed up through the surface. These contain the pycnidia, usually a number crowded together, in which the hyaline spores are formed. The spores escape in great numbers from a small opening in the top of the pycnidia and are the sources of infection from which new cankers may be produced.

A microscopic study of the fungus when it was first found on the cankers showed that it was apparently a species of the genus *Dothiorella*. A study of the literature has been made and it has been found that at least four species of this genus have been described as occurring on either walnuts or willows. Specimens from the Melaxuma cankers on walnut were sent to Mrs. Flora Patterson, Mycologist, Bureau of Plant Industry, who kindly examined them and reported that the fungus could safely be assigned to *Dothiorella gregaria* Sacc. In comparing the specimens on walnut with specimens of *Dothiorella gregaria*, Mrs. Patterson writes, "while the measurements of your material and those given for *Dothiorella gregaria* are not exactly the same, there is no more difference than has been noted in sections made from the latter species as distributed in Cavara-Fungi Longobordiæ exsiccati No. 138 on *Populus nigra.*" The fungus as it occurs on walnuts in California forms dark pycnidia, occurring either singly or in groups. The pycnidia (spore-holding bodies) are flask-shaped, and are 180 to 260 microns* in diameter, with small openings (ostiola) at the outer ends through which the spores discharge. The hyaline, one-celled, spindle-shaped spores are 20 to 26 microns long, and 5 to 7 microns wide, and are born on basidia about 10 to 15 microns long and 3 to 4 microns wide. The measurements of the spores given for *Dothiorella gregaria* by Rabenhorst† are 18 to 22 microns long by 6 to 6.5 wide, and the fungus is reported to occur on Cornus, Populus, Salix, etc., in Italy and France. As far as known the fungus has not been reported to cause any serious injury to trees in Europe.

PROBABLE METHODS OF NATURAL INFECTION.

As was stated before, the usual place for cankers to begin is at the crotches of the large limbs, or at forks of branches, or where a smaller twig joins a main branch. They often start also at injured places at any point on the bark of the trunk or branches.

On an examination of older walnut trees it will be seen that at the crotches or at the angle between branches there are distinct lines of rough bark that have been pushed up and broken by the growth-

*A micron is about one twenty-five thousandths of an inch.

†Kryptogamen Flora, Die Pilze VI, p. 520.

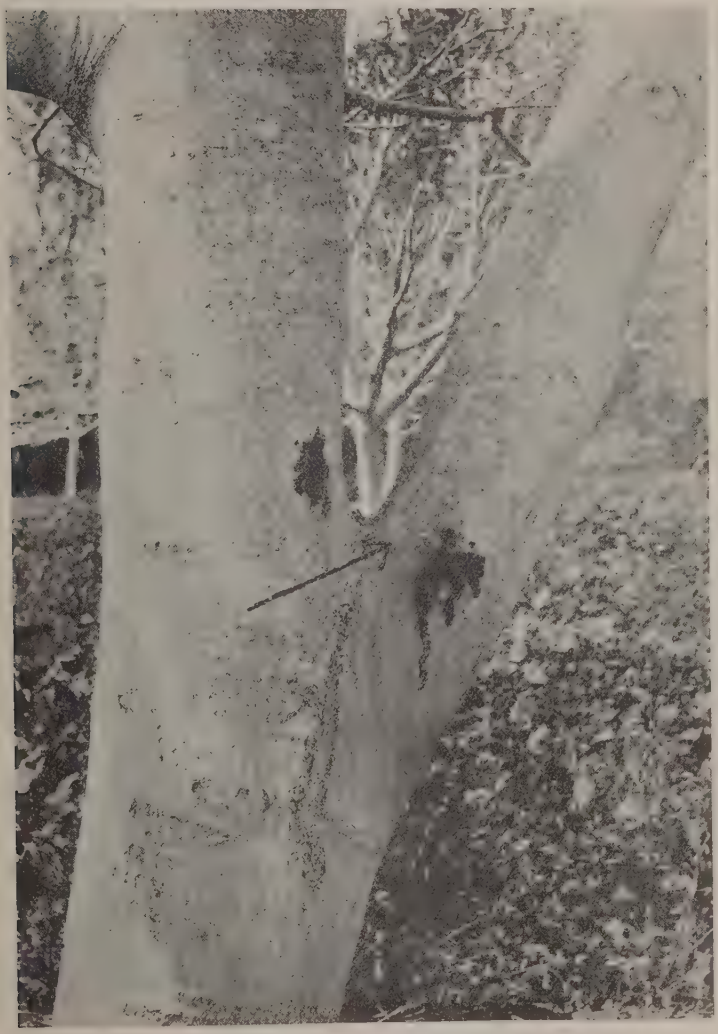

FIG. 2. One of the first evidences of Melaxuma. The black sappy ooze has appeared at the outer edges of the killed bark at the crotch. The bark between has been killed and pycnidia of Dothiorella have already appeared on the surface of part of the killed bark.

pressure of the bases of the two adjoining limbs. These places, with their extra amount of functionless bark cells, are fertile places for the germination and growth of the fungus, which having once become thoroughly established as a saprophyte appears to be able to advance into the surrounding live bark. Severe winds also whip the branches about and probably cause slight cracks at the forks of the branches.

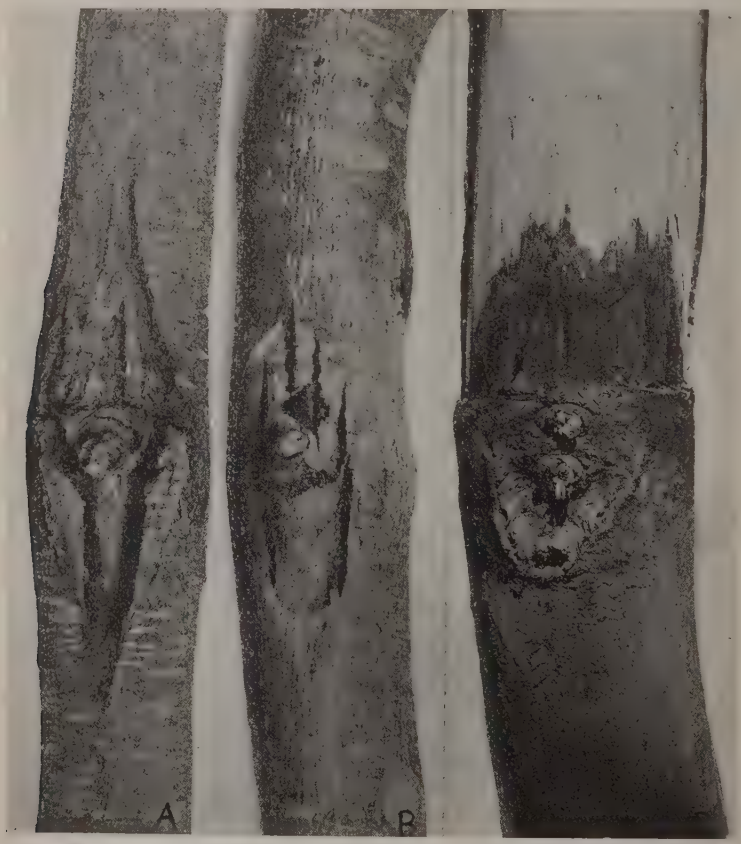

FIG. 3. Melaxuma cankers as they occur on limbs surrounding the base of dead twigs. (A) Old canker on willow. (B) Old caker on walnut. (C) Part of bark of a beginning canker on walnut cut away to show discolored wood underneath.

Another probable entrance for the fungus is in unavoidable injuries to the limbs when the pickers climb the trees or when poles are used to knock off the nuts. In some places also the woodpeckers line the bark with rows of small holes (Fig. 5) which would open up the way for the entrance of the fungus. Then it would seem that the small

twigs, especially on the inside of large trees that are possibly weakened by shading, are attacked and the fungus passes easily from them to the larger branches, thus forming cankers. (Fig. 3.)

EXPERIMENTS FOR CONTROL.

Having proved that the fungus (*Dothiorella gregaria* Sacc.) was the cause of Melaxuma, experiments were started to see what could be done in controlling the disease. Cankers were cut out so as to remove all the diseased bark, as well as the black, killed wood underneath, and the wounds were treated with strong lime-sulphur solution, and with Bordeaux paste (see formula at end of bulletin), the same that had been used for the treatment of citrus gummosis. The results showed that the cankers could be stopped in this way and prevented from enlarging any further. Other cankers, not treated, enlarged till the limbs were killed.

On July 31, 1913, the following experiments were tried on 20-year old trees:

1. A canker 2 by 5 inches, produced by inoculation one month previously with a bit of diseased bark, was cut out. The diseased bark and discolored wood was cut away, leaving a wound 1 foot long and two-thirds the distance around the limb. The wound was painted with Bordeaux paste.

2. An infected area 4 by 5 inches just started on side of trunk, was cut to get out all the blackened tissue which extended only one-half way through the thick bark. The area was then painted with Bordeaux paste.

3. An active canker on a 3-inch limb was cut out so as to remove all discolored tissue, making a wound 1 foot long and one-half way around the limb, and this wound was treated with lime-sulphur paste.

4. The bark on a canker 6 by 6 inches on the side of a trunk was cut away and all discolored wood gouged out and the wound painted with Bordeaux paste.

5. The bark on a large old canker in crotch of tree was cut away well into the live part on one edge of the area, but not on the other. Not all of the discolored wood was cut out. The wound was painted with Bordeaux paste.

6. The same kind of canker in another tree was similarly cut and painted with lime-sulphur paste.

On examination of these experiments on April 29, 1914, about nine months after treatment it was found that in 1, 2, 3, and 4, where the cankers had been carefully cut out, the disease had progressed no further and the cut edges were all healing; 5 and 6 were healing on the side where the bark was cut well into the live part, but were progressing on the opposite uncut side with oozing of black sap.

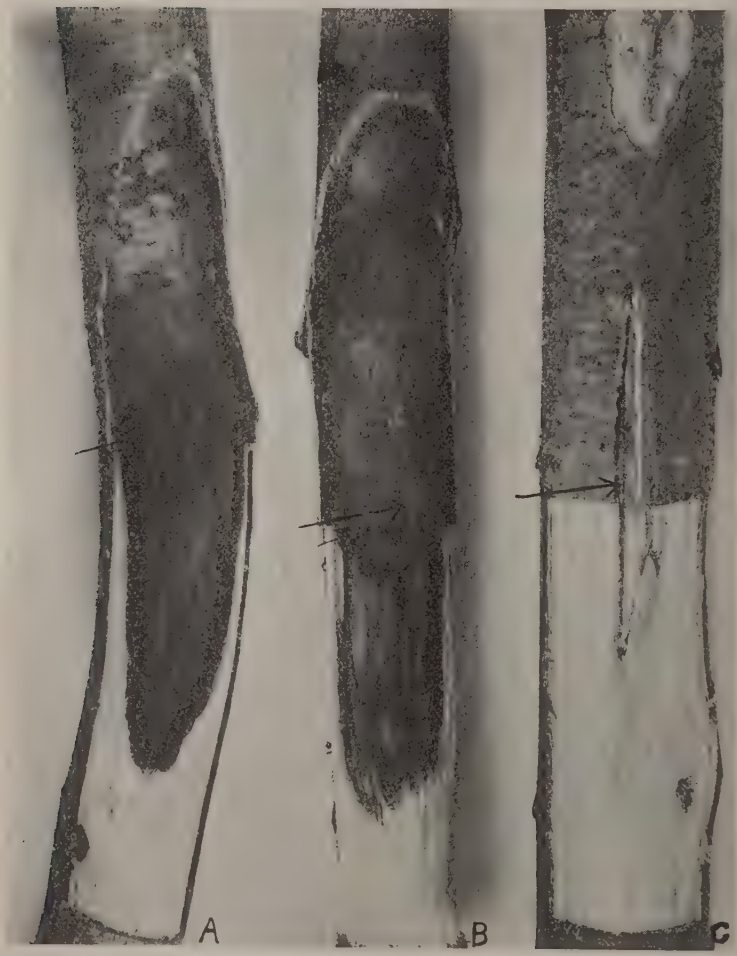

FIG. 4. Two inoculations from a culture of Dothiorella fungus which had been isolated from a Melaxuma canker of walnut, and a check. Arrows indicate the location of the cuts made through the bark. Part of the bark cut away to show the discoloration of the wood in the cankers. (A) Canker on walnut limb four months after inoculation. (B) Canker on willow limb four months after inoculation from same culture. (C) A check cut in another willow limb into which no fungus was inserted, showing no killing of tissue.

In April, 1914, two large cankers in the crotches in two trees were cut, one by getting out all discolored wood underneath, and the other by cutting back to healthy bark but leaving the discolored wood. Both of these later healed well on the cut edges without further enlargement of the cankers.

Further experiments were begun at this time on a larger scale, treating entire trees by cutting out cankers and dead limbs and treating different trees with Bordeaux paste, lime-sulphur paste and asphalt paint. Of these, the Bordeaux paste appeared to give the best average results.

A little later, control work on a larger scale was carried on in co-operation with several large walnut growers in Santa Barbara County. Mr. C. W. Beers, Horticultural Commissioner of Santa Barbara County, has given much assistance in this work. A large grower in Santa Barbara County started cutting out these cankers and dead limbs on a rather extensive scale, having treated more than 100 acres. The work was begun in August, 1914. After cutting out the cankers the areas were covered with Bordeaux paste. Other growers have not only cut out the cankers but painted the entire trunks and crotches of the trees with Bordeaux paste as a prevention against further infection.

The results of this work are so far quite promising. All except a very few of the wounds where cankers have been cut out are healing perfectly without further spread. In treating these trees on a commercial scale, the blackened wood in many of the areas was not entirely cut out because of the expense, and yet in most cases these also seemed to be stopped and showed no activity the next year. In one orchard of about forty acres, the work was more hurried at the last than at the first, the cankers and dead limbs not being cut out so thoroughly. In the part of the orchard treated last, the results are not nearly so good, and a considerable number of cankers are still showing signs of activity. In the part where the work was first begun and executed with more care, very few old cankers show any signs of enlarging.

Experiments in spraying with lime-sulphur and Bordeaux mixture in conjunction with cutting out the diseased cankers are now being carried on. There has not been sufficient time to obtain any data from this later work.

TREATMENT SUGGESTED.

From the observations and results of experiments so far made, the following tentative treatment is suggested:

1. Cut out the cankers that have not gone too far on the trunk and larger limbs and disinfect the wounds thus made. (Fig. 5.) The dead and discolored bark should be cut away, getting a little beyond the

margin of dead tissue. If the cankers are not large and the wood underneath has not been stained deeply, it will pay to dissect out all the discolored wood as well as the bark. Probably one of the best disinfectants to apply to the wound is the Bordeaux paste, the same that is

FIG. 5. Walnut trees showing the location of Melaxuma cankers that had been cut out and treated with Bordeaux paste the year previous. Notice the rows of holes in the bark of one tree, made by woodpeckers. These probably served in this case as partial means of infection.

recommended for lemon gummosis. If the canker is large and has been in the tree a long time, the wood may be stained so deep as to render the work of cutting out all discolored wood too expensive. If the canker has practically girdled the limb (as at X in Fig. 1, B), the limb had better

be cut out. The limb at Y, Fig. 1, B, can probably be saved for a number of years by cutting back into the healthy bark around the edge of the killed area, either with or without cutting out the discolored wood, and disinfecting it. It would be safer, however, if expense in time is not too great, to also dissect out the stained wood, especially if this has begun to soften and decay. Trees need not get to the condition of Fig. 1, A and B, if they are watched from year to year. They may be treated when the areas are starting as in Figs. 2 and 3. Some weeks or months later after it is seen that the progress of the cankers is stopped and the bark is healing at the cut edges as in Fig. 5, the exposed wood should be covered with asphalt paint. If the Bordeaux paste has not been washed away by that time or has not largely peeled off from the wood, the excess may be removed with a wire brush before applying the paint.

2. The limbs with cankers too large to be treated, as well as the limbs already dead, should be pruned out with a saw or pruning shears, making smooth cuts and leaving no stubs. An ax should not be used in pruning. The larger cuts, one inch or larger, may be disinfected with corrosive sublimate, 1-1000 parts of water, and painted with asphalt paint or other good covering. The Bordeaux paste is apparently not so good to use on the cuts made in pruning out limbs.

3. As an added preventive against the development of new cankers in the future, the entire trunks and the crotches of all trees in the orchard (both affected and non-affected) may be painted with Bordeaux paste at small expense per tree. It must be borne in mind in this connection that some new cankers will undoubtedly make their appearance after painting with Bordeaux paste. They will have started unnoticed the fungus having already gotten into or through the bark before the Bordeaux paste was applied, as in Fig. 2. After a year or two when all these have been worked out, the application of Bordeaux paste ought to prevent new ones from forming, except where severe injuries have been made.

4. All injuries to the bark in cultivating the orchards should be avoided. The injury inflicted on the trunks of walnut trees in some orchards in plowing and cultivating is inexcusable. It is a common sight in some orchards to see every third or fourth tree trunk with a large patch of bark torn or wounded by parts of the harness or the edge of the plow, and to see the lower limbs with bark torn off by the harness of the passing team. All these injuries are ideal places for the Melaxuma fungus to enter and start a canker.

5. If willows are growing along the edges of a walnut orchard, it would be well to destroy them or, in case they are useful in keeping the soil from washing, to keep them cut back every year or two. The young

healthy shoots do not seem to be as subject to the disease as older, larger limbs.

Bordeaux Paste. The formula for Bordeaux paste is as follows: 12 pounds of bluestone (copper sulphate) dissolved in 8 gallons of water in a wooden, earthen or glass vessel; and 24 pounds of quick-lime slaked in 8 gallons of water. When the lime is cool, stir together about equal parts by volume of each for making enough mixture to last for one day only. The bluestone is easiest dissolved by suspending it in a sack at the top of the water over night. If the bluestone is pulverized and suspended in warm water it dissolves rapidly. Good lime that is not air-slaked should be used, and after slaking it with the water it should be allowed to cool before being used in making paste. If covered to avoid evaporation each ingredient will keep indefinitely, but after mixing, the paste slowly deteriorates. Where it is being used over a number of days or weeks, just enough of the wet slaked lime and the bluestone solution should be mixed to make paste enough to last for one day, leaving the remainder unmixed in separate vessels. It may be applied with large brushes, as is whitewash.

Asphalt Paint. Good asphalt paint free from impurities may be made by dissolving hard asphalt in benzine or gasoline until it has body enough to form a good covering when applied with the brush. The hard asphalt may either be broken into small pieces and dissolved in the benzine, or the asphalt may first be melted by heating, and after it has been taken from the fire and cooled down somewhat, but not enough to harden again, the benzine poured in and stirred.

Asphalt paint dissolved in benzine and put up in cans ready for use, can usually be purchased at paint shops or hardware stores. A similar article dissolved in turpentine is also on the market, but is not suitable for use on tree wounds.

SUMMARY.

1. Melaxuma, a walnut disease in California, occurring as black cankers on the trunk, crotches, and large limbs, and also occasionally as a withering of small branches, has attracted serious attention in Santa Barbara and Ventura counties in the last two or three years.

2. Experiments have shown that the Melaxuma cankers, as well as the wilting of the branches, are caused by the entrance of a fungus which has been identified as *Dothiorella gregaria.*

3. This fungus was found in the diseased portion of Melaxuma cankers, was isolated in pure cultures, inserted in cuts in healthy limbs, and was found to produce typical Melaxuma cankers on large limbs and the wilting of small branches. The fungus was then reisolated from these artificially produced cankers and found to be the same as that inserted.

4. The same species of fungus was discovered on the arroyo willow, *Salix lasiolepis,* in Santa Barbara County, from which it probably spread to the walnut trees.

5. Experiments and observations would indicate that the disease may be successfully checked by the following methods, the details of which are given on preceding pages: By cutting out the cankers and the dead and weakened limbs and disinfecting the cuts; by painting the crotches and trunks of all trees with Bordeaux paste or other fungicides; by avoiding injuries to the bark; and by keeping willows near walnut orchards cut back.